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India's Nuclear Energy Conundrum: An Assessment of the Country's Energy Futures

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Abstract

This thesis will assess the practicality of implementing nuclear energy into India's power system by considering different security risks, political factors, and COVID-19 complications. Access to energy is essential to modern survival because it contributes to the safety, success, and overall well-being of individuals; allowing for a better acquisition of food, education, and industry necessities. A big concern for India has been the inability to give energy access to millions of citizens that live in no proximity to a power grid, and this has shown to correlate with a lower quality of life. Another concern for India is the search for a cleaner energy source that could serve as a suitable replacement for these environmentally unfriendly sources. Thus, nuclear power is on the forefront of these alternative energy discourses because of its classification as a zero-emission energy source. However, nuclear proliferation is seen as an extremely controversial topic because of its potential to be materialized as a means to disrupt the global order and India's relationship with nuclear power is extremely complex due to its influence on national security. This assessment will include the most recent data found on India's current relationship with nuclear power sourced from a number of scientific journals, government agencies, energy commissions, and academic databases. The ultimate goal is to analyze both the benefits and the potential risks that come with promoting nuclear proliferation and whether the potential of nuclear energy outweigh the hazards.

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One of the defining crises of our time is the effects of climate change and the fact that no person is immune from this issue. News headlines throughout the world say that 'sea levels are rising, ice caps are melting, and forests are burning' and there is this overwhelming sense of dread over the thought of human beings causing irreversible damage to the planet. But global powers are working together on fighting the climate crisis and are taking the initiative to enact transformational changes that could potentially pull us back from the brink of environmental collapse. One such country that is transitioning to greener power and simultaneously working towards providing energy access to millions of citizens is India. This transition is extremely important as India is currently the 3rd largest contributor to global greenhouse gas emissions and so decreasing the country's dependence on fossil fuels is a step in a cleaner direction. Right now, energy experts are saying that nuclear power is the new wave of energy efficiency. With the United States, France, and China all producing massive amounts of nuclear energy it would make sense for India to capitalize off this source and decrease its carbon footprint. However, India has proven to be a nuclear wild card with enormous potential but a history of underachievement.[1] The country's nuclear power industry has remained relatively stagnant and there are no clear answers as to why. Not only that, but the Indian government has set some pretty ambitious nuclear projections that do not match up with the country's current energy output values. Ultimately, this thesis aims to address the question of why nuclear power has not taken off in India and whether it should be something that the Indian government should reconsider post-COVID.

[1] "India 2020 – Analysis." 2020. *International Energy Agency*. https://www.iea.org/reports/india-2020.

Currently, India is in the midst of an urban transformation with 400 million people projected to migrate to the cities by 2050.[2] However, there has been little overall growth in the country's GDP that does not reflect this transition into modern society. A big indicator of the difference in electricity consumption is with the installation of air conditioning units. AC is a threshold good for those within the middle-class income level and for developing countries, air conditioning symbolizes an overall growth in wealth because a stable economy means that this technology becomes more accessible. China has surpassed India in terms of AC installation by a factor of 21 which highlights the mystery of India's slow progress because it has a similarly sized population and a greater need for cooling.[3] This economic stagnation translates to the lack of energy and electricity consumption that is to be expected from India. Thus, the mystery of India's energy impasse has ties to its economic relationships with other countries. India's power sector is the largest component of its total energy demand due to urbanization and overall economic growth. This journey to modernization means that energy growth will be increasingly higher in non-OECD countries, like India. This is opposed to the relative stagnation that Tier 1 countries are displaying in terms of projected energy demand. In terms of energy consumption, MIT (2003) suggested that 4000 kwh per capita should be considered the threshold for the quality of life associated with a developed society.[4] India is currently consuming less than 1000 kwh per capita which is subject to change in accordance to future energy developments. However, due to the advent of technology more people are moving away from rural areas which will increase energy consumption levels. In fact, the majority of the industrialized world will

[2] "World Urbanization Prospects - Population Division." *United Nations*, United Nations, https://population.un.org/wup/.
[3] *India: Three Year Action Plan*. NITI Aayog, https://niti.gov.in/writereaddata/files/coop/20.pdf.
[4] "The Future of Nuclear Power." *Massachusetts Institute of Technology*, 2003, https://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf.

observe little growth in electricity consumption because they have already provided wide energy accessibility that correlated to their respective upticks in energy consumption, but emerging countries like China and India are projecting annual growth rates in the double digits up to 2050.[5] There is little explanation as to why India has not progressed in a manner reminiscent of China's energy growth.

India's Energy Status

Energy efficiency is the magic term when trying to regulate the global energy consumption levels. India is experiencing the beginning of transformative industrialization and while the country is concerned about saving energy, it is favoring strategies that will provide resources throughout the entire country. However, there has been a significant increase in renewable energy utilization after India was named a huge contributor to global gas emissions. The unique challenge is that the growth of its electricity demand has increased so significantly that any energy efficiency proposals have come up short in succeeding long-term. At the 2019 UN Climate Action Summit, PM Modi announced a new target of 450 GW of renewable energy capacity by 2030 and this was motivated by the devastating impacts of climate change along with the country's aversion to expensive energy imports.[6] To understand the need for cleaner energy we have to take a look into India's current energy situation. Right now, India's biggest energy priority is to provide electricity access to 100% of its population. The government use villages as their indicator for electrification so a village is considered fully powered if 10% of its households and public places are connected to the grid; currently, electricity has reached around 85% of the population but the Indian government realizes that energy access is necessary to

[5] India 2020 – Analysis." 2020. *International Energy Agency*. https://www.iea.org/reports/india-2020.
[6] Wadhwa, Vivek. 2020. "Surprise! India Is Leaping Ahead in Clean Energy." *Foreign Policy*. https://foreignpolicy.com/2020/10/22/green-india-energy-climate/.

fulfill basic needs like making food and lighting up homes and so they are committing to electrifying the whole country.[7] Along with prioritizing this development problem, the country is trying to lessen its reliance on fossil fuels to meet energy demands. Thermal power is the largest source of power in India and coal-fueled power makes up around 55% of India's total electricity output.[8] The country has primarily used coal for energy in comparison to other fuels, renewables, and nuclear power. India is also experiencing a massive shift towards urbanization and this means that more people are demanding access to electricity. So, this demand means that the amount of energy consumed has also increased, and the problem is that because of its cost-effectiveness and ready availability, coal is what is used to meet these enormous demands. There is a general understanding about the fact that coal production contributes heavily to air pollution but to fully understand why it has such adverse effects we must have a basic understanding of how a coal power plant works. Coal is burned inside of a boiler and the water evaporation triggered by this creates steam that turns turbines that are connected to generators. The problem with the coal plant occurs at the very beginning of the process with the burning of coal itself. When coal is burned it releases a number of toxins that increase carbon emissions which is terrible for the environment. The debris from coal plants include contaminants like arsenic and mercury which are known to pollute waterways and the atmosphere. Coal ash is known as one of the largest types of industry wastes and India generated 217.4 million tons of ash in 2018-2019.[9] The reality is that coal power constitutes around 75% of the country's energy profile, as a whole. This is why India is setting ambitious plans to increase renewable energy because if it doesn't

[7] Nazmi, Shadab. 2019. "India Election 2019: Bringing Power to the People." *BBC News*. https://www.bbc.com/news/world-asia-india-47499917 (November 11, 2020).

[8] "Global Energy Perspective 2019: Reference Case." 2019. *Energy Insights*.

[9] Yashwant, Shailendra et al. 2020. "Coal Ash Is a Serious Hazard to Our Health and the Environment." *India Climate Dialogue*. https://indiaclimatedialogue.net/2020/07/27/coal-ash-poses-serious-environmental-and-health-hazards/.

then there will be a huge increase in global emissions. In accordance with the Paris climate agreement, the country is pushing for the expansion of renewable energy in its overall energy consumption due to the shortage of fossil fuels, and the detrimental environmental impacts of the primary utilization of coal.

Rise of Nuclear Power

The global commitment to address the adverse effects of climate change is what has renewed interest in nuclear power. Nuclear technology uses the energy released by splitting the atoms of specific elements (e.g. uranium) for more peaceful intentions.[10] This non-weaponized option of "going nuclear" has the huge advantage of being an emission-free source. This form of energy generation does not produce greenhouse gases and as such is proven to be a huge step towards expanding clean energy options. Not only that, but it is a relatively reliable source of energy because reactors run with little to no downtime and are not dependent on external factors. As opposed to renewable energy, where solar power requires exposure to sunlight, hydropower relies on the presence of water, and wind power which requires consistent air pressure. This is an enormous advantage because India has communities that are in need of a stable source of electricity and one can place a nuclear reactor wherever they wish, so long as they abide by environmental and regional guidelines. Nuclear power is also seen as cost competitive with other forms of electricity generation, other than low-cost fossil fuels, because while they are expensive to build once they are up and running, they prove to be conveniently cheaper to run. Plants are expected to operate for 60+ years, and fuel costs are only a minor portion of operating costs and those have proven to be lower than renewables.[11] There is no dispute that nuclear energy in an

[10] Nuclear Power in the World Today." 2020. *Nuclear Energy - World Nuclear Association*. https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx.

[11] "Economics of Nuclear Power." 2020. *Nuclear Energy Costs - World Nuclear Association*. https://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx.

idyllic global environment is a very good opportunity to promote clean energy, but of course, there are also a number of disadvantages that come with nuclear power. The ones that will be mentioned in this thesis are the costs of building these reactors in the midst of a global pandemic, and the growing dissent among the Indian public against creating reactors in their proximity. This along with the global fear post-Fukushima have made it so that the Indian public is generally fearful of what the implications of nuclear power hold.

Before we go into those reasons, we must address why India has shown interest in going nuclear. The dirty fuel situation caused by coal is what has driven the investment for nuclear power with a projected nuclear contribution of 25% being India's ambition for 2050. Nuclear energy has been a popular topic in India as it operates around 22 reactors, but it only constitutes 3% of total electricity consumption.[12] India's nuclear future has been fairly ambiguous due to its miniscule rate of growth in comparison to China's nuclear growth. There have been no new reactors connected to the electricity grid in the past year, and seven other reactors remain under construction. The way in which India has handled nuclear concerns helps to understand the distinction between the country's ambitious projections and its actual nuclear capability. India has a renewed interest in going nuclear because it was one of the first countries to grasp the significance of nuclear energy. In 1947, PM Nehru launched the nuclear program meant to boost India's self-reliance on energy through the production of relatively inexpensive electricity with the added bonus of being able to develop its weapons program.[13] There have been a number of political and military decisions since the advent of the country's nuclear industry that have led

[12] "Nuclear Power in India." 2020. *Indian Nuclear Energy - World Nuclear Association*. https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.

[13] "Nuclear Power in India." 2020. *Indian Nuclear Energy - World Nuclear Association*. https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.

India to conduct itself as an isolated nuclear power. Thus, the mystery of India's lackluster nuclear performance ties to it being largely independent in this source of energy.

India's Call for Nuclear Security

The investment in nuclear power is not solely limited to energy purposes as the inevitable access to resources will allow for the further development of India's nuclear weapons program. Nuclear proliferation is best known as the new wave of modernized military strategy, in the context of potential security threats. And, a natural result of economic and military modernization is the increase in both internal and extrinsic security challenges, and India is currently facing threats that will increase its nuclear stance. The desire to build one's nuclear weaponry goes hand in hand with the security risks a country is facing. And, while India has previously stated that nuclear weapons are political weapons and seemed more inclined to capitalize on the threat of MAD rather than partake in any violence, the Modi administration takes on a more aggressive stance especially in the face of the border issues occurring at the LAC and LOC.

One of India's biggest security issues concerns the contested boundary, known as the Line of Control. The LOC is a mere representation of the actual territorial dispute with Pakistan over the region of Kashmir. Providing historical context helps to understand the rivalry between India and Pakistan, and the partition of 1947 resulted in the prior British colony being split into these two nations based on their religious majorities. This sudden separation led to millions of people relocating to the country that promoted their beliefs, but not without suffering the consequences of religious violence. This was not a smooth transition and there was still the matter of both nations sharing a border with Kashmir; giving way to conflicts over which country would gain this region. The expectations were for Jammu and Kashmir to go to Pakistan

due to its majority Muslim population and geographical location. However, the Maharaja agreed for Kashmir to submit to India in return for military assistance, and as a result, there have been three wars and a number of conflicts fought in regard to the accession over these regions. The first war in 1947 concerned the overall accession of Jammu and Kashmir; resulting in the establishment of a ceasefire line. The second war in 1965 began when Pakistan launched their secret mission, Operation Gibraltar, to send 30,000 men into Kashmir to start a revolt and break India's hold on the region[14]. The conflict ended with a ceasefire and the two countries agreed to return to their pre-war territorial status. The last armed dispute was in 1999, and started when Pakistan infiltrated the LoC near Kargil, but ultimately Indian forces regained possession of this land.[15] Kashmir has remained one of the most militarized zones in the world, and feelings of unrest have only escalated due to the development of both Pakistan and India's nuclear capabilities.

Nuclear proliferation plays a big role in the defense programs of both nations, and this element makes it so that the Kashmir conflict has the potential to have detrimental consequences. The military crackdown of Pakistan included the convening of the National Command Authority, which has the authority to authorize a nuclear strike, but India has remained true to the conventional methods of warfare in response to the recurring terrorist attacks led by Pakistani militant groups. Pakistan has turned to nuclear weapons in order to counter India's military strategies. The acceleration of Pakistan's nuclear program was a result of India's pursuance of

[14] Khan, M Ilyas. "Operation Gibraltar: The Pakistani Troops Who Infiltrated Kashmir to Start a Rebellion." *BBC News*, BBC, 5 Sept. 2015, https://www.bbc.com/news/world-asia-34136689.
[15] Riedel, Bruce. "How the 1999 Kargil Conflict Redefined US-India Ties." *Brookings*, Brookings, 24 July 2019, https://www.brookings.edu/blog/order-from-chaos/2019/07/24/how-the-1999-kargil-conflict-redefined-us-india-ties/.

nuclear weapons, and a result of the country's defeat during the Indo-Pakistani War of 1971.[16] The loss of East Pakistan is said to have really prompted Pakistan to embrace nuclear developments. This escalation of modern warfare means that India and Pakistan must tackle a potential nuclear arms cooperation agreement, lest they find themselves in a military standoff.

Another border dispute is occurring at the LAC which is the border that distinguishes the Indian and Chinese disputed territory, Aksai Chin, and is the symbol of another huge security risk for India. Similarly, to the border dispute with Pakistan, India is currently engaged in another boundary tiff with China which has produced its fair share of violent military standoffs. The Karakoram Mountain Range spans along the borders of China, India, and Pakistan and the region in question, Aksai Chin, is located in the boundary line between the former two countries. India has claimed ownership over this territory, but currently it is in the control of Chinese forces. Once again, one can pinpoint the root of this conflict to the consequences of colonialism as it was British forces that gave India a border with China that was never authenticated. So, these two global powers have spent decades trying to formalize their respective borders at the expense of their nation's security. The 1962 Sino-Indian marked the height of tension over this Himalayan border and Chinese forces advanced on Indian troops after India failed to recognize any of China's proposed settlements.[17] The war concluded as a result of a ceasefire and the mutual agreement for both countries to adhere by the 'Line of Actual Control'. Recently, China's Belt and Road Initiative has made it so that the country has a renewed interest in maintaining its claimed ownership of the land as it would serve as an essential link for the completion of China's massive infrastructure projects. India's continuation of asserting dominance in regard to this

[16] Kidwai, Rasheed. "How the 1971 War Was Fought and Won." *ORF*, https://www.orfonline.org/research/how-1971-war-fought-won/.
[17] Shukla, Ajai. 2020. "How China and India Came to Lethal Blows." *The New York Times*. https://www.newyorktimes.com/2020/06/19/opinion/China-India-conflict.html

region is seen as a threat to China's sense of sovereignty. These unresolved conflicts have created a fairly hostile atmosphere and the summer of 2020 included a military standoff at the border that led to the death of 20 Indian soldiers and caused a number of Chinese casualties.[18] Chinese military presence has exponentially increased and it has triggered a reevaluation of India's state of security. The incident at the LAC significantly soured relations between the two countries and although neither country has explicitly used nuclear power as a threat, the mere acknowledgement of both of their nuclear statuses cannot be ignored.

As challenges along the borders with China and Pakistan persist, India's inclination to focus on manpower to fortify itself against these border transgressions is guaranteed. Of course, all of these global powers being nuclear states does elevate the volatility of the conflicts and raises questions of the extent to which they could be escalated. But, as of now India has been unable to commit itself to investing in "deep-strike capabilities" against Pakistan which alludes to the use of nuclear weapons, and China is lightyears ahead of India in regard to nuclear development so the likelihood of India touting its nuclear propensity is very little.[19] Right now, India's nuclear capabilities are not at a point where they can be considered a sufficient MAD strategy, and so the country is working on fortifying its conventional military capacities in the face of a two-front war. All of this to say that India is currently working to modernize its nuclear arsenal and if one were to solely compare its weaponry to Pakistan there would be a greater indication of a potential nuclear standoff, but recent events have made it so that India cannot withstand nuclear threats from both China and Pakistan. It is an extremely complicated scenario

[18] Tellis, Ashley J. "Hustling in the Himalayas: The Sino-Indian Border Confrontation." *Carnegie Endowment for International Peace*, 4 June 2020, carnegieendowment.org/2020/06/04/hustling-in-himalayas-sino-indian-border-confrontation-pub-81979.
[19] Rajesh Bansal, Anirudh Burman. 2020. "Recovery, Resilience, and Adaptation: India from 2020 to 2030." *Carnegie India.* https://carnegieindia.org/2020/09/21/recovery-resilience-and-adaptation-india-from-2020-to-2030-pub-82721

because India has not been able to capitalize off of nuclear power and so the country is not really considered a strategic threat but more of a regionally proximate rival. So, in the face of this new threat India is attempting to pursue more aggressive nuclear strategies and is putting out hopeful projections for nuclear power.

Reasons for Nuclear Stagnation

So, why has India not been able to utilize nuclear powers like other countries (e.g. China) been able to? A possible explanation for this nuclear stagnation is that the stance that India took on during the height of nuclear proliferation had an enormous impact on the growth, or lack thereof, of the country's nuclear sector. In the past, India had firmly believed that nuclear usage serves a political purpose and has stated that its goal is to 'reduce nuclear danger' by promoting global disarmament.[20] This is one of the reasons why India has refused to sign the Treaty on the Non-Proliferation of Nuclear Weapons unless the member states agree to have a cohesive plan for de-escalation. The country's refusal to enter into the NPT was meant to be an example for other countries to move towards a nuclear-free future, but it resulted in India being excluded from nuclear trade. To give more context, the NPT is an international treaty meant to prevent the spread of nuclear weapons and work towards nuclear disarmament, but only at the expense of giving countries power based on their dichotomous categorization as either a nuclear or non-nuclear state. This 'either-or' fallacy was a contributing factor to India's hesitancy to join, but the main reason was that the country would have to be considered a 'non-weapons' state because it joined after 1970, and as such would not be permitted to hold weapons. India had problems with this because the lack of nuclear weapons would place it in a relatively weaker position in

[20] Piper, Kelsey. "Study: A Nuclear War between India and Pakistan Could Lead to a Mini-Nuclear Winter." *Vox*, Vox, 9 Oct. 2019, https://www.vox.com/future-perfect/2019/10/9/20903418/study-nuclear-war-india-pakistan-could-lead-to-mini-nuclear-winter.

the face of external security threats. The fact that some countries got to claim nuclear status while others could not in the name of 'global disarmament' totally undermines the military sovereignty of India and so the country disputed this treaty by questioning why all countries could not commit themselves to global disarmament instead of introducing a strategic power dynamic. Because India refused to sign, the country was denied access to "peaceful nuclear technology" from nuclear countries and this trade restriction prevented India from obtaining nuclear resources to develop their nuclear program. This lack of resources and knowledge did indeed obstruct the development of civil nuclear energy, and by the time that India was enabled to engage in international trade it was miles behind its energy projections. PM Modi claims that India's irreversible dependence on coal is because it was barred from the Nuclear Suppliers Group.[21]

Another inhibitor of nuclear proliferation is the fact that India does not have an enormous reserve of indigenous uranium. Thus, the development of a nuclear fuel cycle that utilizes thorium has been implemented. But this elemental transition is bound to take time due to the development of new technology and safeguards to ensure the longevity of the power plants. India has started to look for nuclear fuel suppliers to make up for its lack of performance in the past years. India and the United States have made a deal which was to import reactors from the U.S. and France, but so far construction does not seem to be imminent and this deal could be perceived as just another political strategy to show other countries that India has strong allies. India has also signed a deal with Uzbekistan for a long-term supply of uranium to power its reactors, and is sourcing fuel from Uzbekistan, Russia, and Canada. This dependence on imports is a threat to economic stability because India's main goal is to increase its economic

[21] [21] Kumar Singh, Rajesh, and Ashutosh Joshi. "Modi Rues India's Omission from Nuclear Group in China Swipe." *Bloomberg.com*, Bloomberg,

autonomy and in working towards decreasing its dependence on coal imports the country must find the most feasible option.

There have been protests from citizens against the plans to conduct exploratory mining for more uranium in the southern region of India. There is a staunch 'not in my backyard' way of thinking from various social groups. Environmentalists are protesting the excavating of uranium because the chosen locations are rich in nature and contain large tiger populations; resulting in a pause in the mining approval process.[22] Local farmers have made allegations that the mining process will contaminate the soil and water reserves which is detrimental to the farming industry. The protests at India's largest nuclear power system, the Kudankulam nuclear plant, in Tamil Nadu have persisted since it was first proposed in the 1970's. Kudankulam became operational in 2013 and protesters claim that the plant releases toxins into the sea which deteriorates the quality of fish[23]. As this is the main source of livelihood for citizens living in Tamil Nadu, the public fears that the plant will ruin their chances of achieving prosperity in their community. Along with these more environmentalist concerns, there have been an uptick in protests after the 2011 nuclear incident at the Fukushima plant in Japan. India is also prone to natural disasters and so there is this fairly rational fear that citizens will have to deal with the devastating consequences of a nuclear meltdown which would best be dealt with by avoiding the implementation of nuclear power, as a whole. These protests have done a sufficient job in preventing the acquisition of new materials from an administration level. If India is truly hoping for its nuclear capacity to be 22.5 GW by 2031 then gaining the support of the citizens on the

[22] Miner, Ag Metal. "The Biggest Hurdle in India's Nuclear Energy Push." *OilPrice.com*, 5 Oct. 2019, https://oilprice.com/Alternative-Energy/Nuclear-Power/The-Biggest-Hurdle-In-Indias-Nuclear-Energy-Push.html.
[23] Daga, Sweta. "The Women Protesting the Kudankulam Nuclear Plant." *The Caravan*, 2 July 2019, caravanmagazine.in/communities/women-protest-kudankulam-nuclear-plant.

nuclear debate should be a top priority.[24] The people do not know enough to understand the benefits of utilizing nuclear energy, so educating the public is something that should be considered. Not only that, but because the Indian government, rather than private companies, is in charge of the nuclear sector there must be an entity that advocates for the rights of the civilians that have to live in proximity to these reactors. There are a number of factors that explain India's uncertainty when it comes to nuclear energy, but it consistently goes back to its economic state.

Covid-19 Complications

The outbreak of this global pandemic has already been shown to utterly devastate the global economy, destroy worldwide health securities, and it has indeed impacted the future of energy production. The outbreak has been a massive blow to worldwide energy systems and nuclear power is projected to decline by 3% this year.[25] Energy demand has decreased in the industrial sector due to lockdown procedures but this has caused an increase in residential energy demand. This means that it is more important than ever to connect people to the electricity grid because people must stay indoors. COVID-19 has also had a tremendous impact on India's economic progression, or lack thereof, with emerging economies having to use this supposed recovery time as a chance to address long-standing economic problems. Preexisting economic shortcomings have more devastating consequences when tied to the fallout from the pandemic and India must find a way to recover from this combined financial crisis to return to a somewhat stable path, and as such, merely surviving the pandemic is not an option.[26] India's plans to uplift

[24] "Nuclear Power in India." *Indian Nuclear Energy - World Nuclear Association*, https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx.
[25] "Global Energy Demand to Plunge This Year as a Result of the Biggest Shock Since the Second World War." 2020. *iea.org*. https://www.iea.org/news/global-energy-demand-to-plunge-this-year-as-a-result-of-the-biggest-shock-since-the-second-world-war.
[26] Rajesh Bansal, Anirudh Burman. 2020. "Recovery, Resilience, and Adaptation: India from 2020 to 2030." *Carnegie India*. https://carnegieindia.org/2020/09/21/recovery-resilience-and-adaptation-india-from-2020-to-2030-pub-82721.

its economy and update its military have been put on the back burner because of the financial freeze that the pandemic has triggered. Before the pandemic, India was emerging as a global superpower with an increasing military presence and a relatively open economy, but the complications of this outbreak include the reemergence of the organized state and rising nationalist sentiments that impact both domestic and transnational proceedings. Each country has had to engage in a sort of economic nationalism that pursues the best interests of the country at hand. This is what has spurred on the questioning of nuclear power as the most financially practical option in the midst of this global crisis.

The lockdown measures have also slowed nuclear power construction activity. A number of reactors have remained under construction and the completion of these projects is likely to be pushed by to a later date in 2021. From an operational stance, nuclear plant performance has remained unchanged during the lockdowns with the safety of workers taking precedent in these uncertain times. For those working in nuclear plants, there have been a number of safety precautions set in place by nuclear experts in an attempt to mitigate production loss while also ensuring worker safety. So, underperformance cannot be attributed to COVID precautions but there is the threat of the demise of nuclear power because of the lack of continued investment in the nuclear sector. Revenues from supplying energy have been increasingly low which counters the argument to invest in extending the lifespan of these nuclear plants or putting more money into creating new ones.[27] Because India's nuclear program has conducted itself without the resource or technological assistance from other countries as a result from its exclusion from the Nuclear Suppliers Group, it has underperformed by international standards. This is not solely

[27] "The Covid-19 Crisis Is Undermining Nuclear Power's Important Role in Clean Energy Transitions – Analysis." 2019. *IEA*. https://www.iea.org/commentaries/the-covid-19-crisis-is-undermining-nuclear-power-s-important-role-in-clean-energy-transitions

attributed to the performance of existing reactors, but because proposed nuclear projects have been rejected and so this sector has not been given a chance to expand. One such project includes the American nuclear company, Westinghouse, and its allotted project for the creation of 6 nuclear reactors.[28] The Nuclear Power Corporation of India was forces to abandon this project because it did not clear environmental regulations. The fact of the matter is that the nuclear program has been continually delayed rather than outright canceled, but this lack of performance has only been met with higher projections from India's Department of Atomic Energy. The government of India announced for the construction of seven additional reactors to its preexisting 22 reactors, and there has been paperwork done for the addition for 12 more reactors but even before the outbreak of the pandemic, nuclear plant construction was supposed to increase by leaps and bounds by 2020.[29] The effects of the coronavirus will mean that plant construction will be continue to be extended until India can assume a stable working environment.

The aforementioned section discussed India's financial state in relation to the foreign energy imports it must conduct to run its nuclear reactors. The uranium industry has been dealing with the effects of COVID with countries, like Canada, suspending their mining operations to prevent the spread of the virus. Because India imports uranium from Canada, and several other countries, this suspension will have a significant effect on the manufacturing of Indian nuclear reactors. There is a sort of trickle-down phenomenon that makes it so that the production levels of India's suppliers have a strong correlation to India's performance because it relies on those countries for supplies it cannot provide for itself. For so long, India's nuclear program has

[28] Sundaram, Kumar. 2019. "Has India Really Scaled Down Its Nuclear Power Ambition?" *DiaNuke.org*. https://www.dianuke.org/has-india-really-scaled-down-its-nuclear-power-ambition/.
[29] India 2020 – Analysis." 2020. *International Energy Agency*. https://www.iea.org/reports/india-2020.

remained self-sufficient but the country's uranium reserves are running dry and so to keep up with energy demands it must turn to external suppliers for nuclear components. So, as the country is working to become less dependent on costly energy imports nuclear power is less appealing in comparison to home-sourced energy forms. Overall, India must try to revive its economy without compromising its goals of achieving energy efficiency.

Alternative Energy Sources

India has committed to making its energy portfolio greener and as such has looked into different energy sources that could be named a sufficient replacement for the massive contribution that coal has made in India's energy profile. The main prerogative of this transition to clean energy should be for India to stay on course towards providing total electrification and as such there needs to be a discussion on which option is both temporally and financially feasible. It is not a matter of whether nuclear power is beneficial in the long run, because it has proven to be just that, but in India's case there are too many confounding factors that make these benefits rather obsolete. The Indian government does not want to go from decreasing its dependence upon other countries for coal imports to depending on countries for uranium imports, and so the administration is focusing on alternative sources to meet its massive energy demand. India is in the unique position to be able to consider options that include using elemental variations of nuclear power, cleaner variations of fossil fuels, and a potential reconfiguration of renewable energy production.

Thorium Replacement

The discussion of the scarcity in uranium supplies begs the question of why this specific element is used for nuclear reactors, in the first place, and whether another element should be used to meet new energy demands. As stated before, nuclear power is inextricably tied to the

proliferation of nuclear weapons which is why uranium ore is what is used to power nuclear reactors. The byproducts of this specific radioactive element have been proven easier to weaponize which is why it has been a rather inelastic commodity within the nuclear sphere. However, because India's uranium supply is dwindling and the country is looking to decrease its dependence on foreign energy imports it has led to the exploration of other fuel sources. And as stated above, the first option India is able to consider mentions the continued use of nuclear power albeit using a totally different fuel cycle. This fuel replacement is possible thanks to the fact that India has an enormous reserve of home-sourced thorium found in the sands of its beaches. This resource abundance means that India has put great stock into potentially utilizing its estimated "300,000 to 850,000 tons of thorium" but so far progress has been slow with implementing this fuel replacement into nuclear power processes.[30] To explain its shortcomings, there must be an understanding of how a nuclear power plant works to generate electricity in the first place. Inside of conventional nuclear reactors, rods of uranium ore are bundled together and placed under water. Once the reactor is on, neutron particles hit the uranium atoms and cause them to split. The energy produced in this fissile process creates a chain reaction which increases the momentum of the produced energy. This energy buildup is what heats up the water and causes it to produce steam, and the massive amount of pressure caused by the steam is what rotates a turbine. This turbine is connected to a generator and the spinning motion converts kinetic energy into mechanical energy which is what allows for electricity to be generated. So, uranium has the capacity to engage in these nuclear reactions but thorium, on the other hand, cannot power a reactor because it is not sufficiently fissile, meaning that it cannot withstand the

[30] Gent, Edd. 2018. "Why India Wants to Turn Its Beaches into Nuclear Fuel..." *BBC Future*. https://www.bbc.com/future/article/20181016-why-india-wants-to-turn-its-beaches-into-nuclear-fuel.

process of nuclear fission and even less so with the chain reactions that are needed to produce energy. This inability to undergo spontaneous fission means that there must be another element that is introduced to trigger such a reaction. This extra step of converting thorium into being susceptible to fission is part of India's energy strategy, but it requires the continuation of conventionally fueled reactors. Uranium reactors produce a byproduct of plutonium which can be combined with thorium to create the necessary reaction but this means that uranium reactors must be put into use at a higher rate.[31]

But, how can India continue to use uranium reactors at an even more accelerated rate if it is running out of its uranium supply? There is also the requirement of having operational experience before the expansion of thorium projects can even be possible and this is why energy experts state that India is unlikely to generate sufficient energy from thorium until at least the 2050's.[32] Conventional nuclear power is already seen as quite the investment so adding the extra costs of developing thorium-specific reactors along with developing the plutonium enrichment process is just not feasible if one is looking for a widespread and effective solution. By the time India conducts the studies and invests money into thorium reactors the energy deficiency will be at an all-time high, so there must be an alternate replacement while thorium processing is being experimented. The devastating effects of the COVID-19 pandemic have made it so that India cannot afford to lose any money in investing in projects that have no direct contribution to its goals of providing total electrification while also achieving economic independence.

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[31] "How Is Uranium Made into Nuclear Fuel?" *World Nuclear Association - Nuclear Essentials*, www.world-nuclear.org/nuclear-essentials/how-is-uranium-made-into-nuclear-fuel.aspx.

[32] Gent, Edd. 2018. "Why India Wants to Turn Its Beaches into Nuclear Fuel..." *BBC Future*. https://www.bbc.com/future/article/20181016-why-india-wants-to-turn-its-beaches-into-nuclear-fuel.

Reasonable Pricing for Oil and Gas

Efforts to provide green alternatives are not limited to these renewable options, and although they are the most beneficial for the environment just moving away from coal production is a huge step in the right direction. This is why PM Modi is urging for oil and gas suppliers to adjust their pricing in the wake of the pandemic because a transparent market will allow for an easier transition towards cleaner energy.[33] Because India has remained so coal-dependent, any attempt to wean off of this source will significantly aid the country's efficiency goals. Although natural gas and oil are still considered fossil fuels, global emissions from these are significantly lower than those of coal. Natural gas, specifically, emits 50-60% less CO2 when used for energy generation than in a modernized coal plant.[34] There is the realization that because of the pandemic, transitioning to a fully renewable energy profile is going to be much more difficult and so energy experts are taking smaller steps towards erasing its carbon footprint and even this decrease will have major benefits. While this form of energy still produces a certain level of carbon emissions, it does not include the harmful added toxins that coal production contributes, and just weaning off of the huge dependence that India has on coal will make a substantial difference. Natural gas introduces an element of flexibility that renewables are not able to supply as of yet, but creating a stable fuel cycle will allow for a stronger expansion of renewable energy.

[33] India Will Drive Global Energy Demand: PM Modi." 2020. *NDTV.com*. https://www.ndtv.com/india-news/pm-narendra-modi-india-will-drive-global-energy-demand-2316043.
[34] "Environmental Impacts of Natural Gas." 2014. *Union of Concerned Scientists*. https://ucsusa.org/resources/environmental-impacts-natural-gas

Renewable Energy

An energy source that can guarantee an emission-free power system with a low risk of meltdown and an even lower risk of potential weaponization is the use of renewable energy. Just like in the nuclear industry, the renewable sector is facing significant delays thanks to the pandemic but the difference is that India has made a significant amount of progress in expanding renewable energy. Currently, renewable energy makes up a sizable portion of India's electricity capacity and is projected to continue in growth. Focusing on renewables would allow for India to gain energy independence and decrease its reliance on foreign imports. Under the Paris Agreement, India pledged to increase the share of power generation capacity that is not sourced from fossil fuels to 40% by 2030, and India is currently on track to exceed this target goal, generating around 38% of its power from non-combustible energy.[35] Advances in green technology have made it so that India is able to exceed its energy efficiency goals as prices in renewable energy resources have dropped significantly. Stabilizing the carbon emission induced changes in the atmosphere is primarily an energy problem, and so implementing solar, hydro, and wind power is appealing because they are sourced from naturally occurring environmental events, and mitigating climate change requires sources that that do not emit toxins into the environment. In terms of solar power, when the first panel was created by Bell Labs in 1954 it cost around $1000 per watt of generated electrical power; fast-forward to 2008 and solar array components cost around $3.65 per watt, and most recently the 2018 cost analysis report shows it to cost less than 40 cents.[36] In India, these decreasing prices have made it so that solar power generation has become cheaper than coal-powered energy which in turn has allowed for the

[35] Wadhwa, Vivek. 2020. "Surprise! India Is Leaping Ahead in Clean Energy." *Foreign Policy*. https://foreignpolicy.com/2020/10/22/green-india-energy-climate/.
[36] Wadhwa, Vivek. 2020. "Surprise! India Is Leaping Ahead in Clean Energy." *Foreign Policy*. https://foreignpolicy.com/2020/10/22/green-india-energy-climate/.

country to exponentially increase its solar power generation. In fact, India has actually made green history this year with a levelized first-year cost of 2.90 rupees per kilowatt-hour, it will be among the world's lowest rate for uninterrupted renewable power which finally makes the both the generation and storage of clean energy cheaper than burning coal.[37] So far, renewables have been seen as a costly investment but this new rate has huge implications for the future of this energy source.

Another problem with renewable power is the fact that it's intermittent. The sun does not always shine, wind is not consistent, and access to water is not always guaranteed. One potential answer to this regularity problem is through the advent of battery technology. In the past, fossil fuels have had to serve as a back-up to these on-again, off-again green energy solutions. But battery storage systems can be used to store excess generation and provide reliable electricity to isolated and off-grid communities, and costs of this technology have dropped due to the "growing consumer market and the distribution of renewable energy generation".[38] India's biggest problem is providing electricity access to citizens who are in no proximity to an electrical grid and this technology can potentially fix this issue while also promoting cleaner energy standards.

What makes India a good candidate for alternative energy sources is the fact that the country has very unique geographic conditions that have not been used to their maximum potential. With landscapes ranging from the Himalayan mountain ranges, to deserts in the central regions, and a long coast unique to the Indian peninsula, there should be renewed interest in investing into the resources that are readily available in India. Solar energy intensity varies

[37] Wadhwa, Vivek. 2020. "Surprise! India Is Leaping Ahead in Clean Energy." *Foreign Policy*. https://foreignpolicy.com/2020/10/22/green-india-energy-climate/.
[38] Battery Storage Paves Way for a Renewable-Powered Future." 2020. *International Renewable Energy Agency*. https://www.irena.org/newsroom/articles/2020/Mar/Battery-storage-paves-way-for-a-renewable-powered-future

geographically in India, but northern region of Rajasthan receives the highest annual solar radiation energy.[39] This is where the world's largest solar plant, the Bhadla Solar Park, is located because the dry and arid desert landscape is ideal for solar power. In terms of water power, there have been projects that are planted along the coastal regions of India, but there should be an added implementation of hydro projects alongside mountain ranges so that water runoff from the mountains can be used to generate electricity. This would allow for India utilize its natural resources without defacing any of the natural resources or interrupting needed water sources. Such, projects have been explored with the Himalayan hydro-plant in the Himachal Pradesh region which has connected to these isolated communities to the electricity grid and has ushered in some much-needed development and monetary benefits to the local people.[40] By separating the country into regions that have the abilities to harness specific renewable powers it can extend electricity grids to regions that may not have conventional access to electricity grids but the implementation of these projects can empower these specific localities. Ultimately, the lower labor costs that come with the installation and maintenance of renewable energy generation are more effective especially in the wake of a global pandemic. As, India imports the vast majority of its coal, oil, and nuclear supplies from foreign powers it would make sense for the administration to welcome home-sourced power capabilities. The Rockefeller Foundation and Tata Power have collaborated in efforts to set up 10,000 microgrids by 2026 to connect more than 5 million households to small distribution networks of local renewable power, and so these localized renewable projects are garnering international interest.[41] Renewable energy has made

[39] Meena, Radhey Shyam, et al. "The Most Promising Solar Hot Spots in India Development and Policy: The Thar Desert of Rajasthan." *International Journal of Engineering Development and Research*, vol.3, no.1, 2014
[40] "A Hydropower Project Brings Development to Himalayan Villages." 2014. *World Bank* https://www.worldbank.org/en/news/feature/2014/07/16/a-hydropower-project-brings-development-to-himalayan-villages
[41] Wadhwa, Vivek. 2020. "Surprise! India Is Leaping Ahead in Clean Energy." *Foreign Policy*. https://foreignpolicy.com/2020/10/22/green-india-energy-climate/.

some remarkable strides in India and an improved focus on renewable energy spending within India's energy transition could ensure an eco-friendly recovery from the global Covid-19 crisis.

Conclusion

There has been an international undertaking of clean energy transformations in efforts to minimize the damage done to the planet by the adverse effects of human development. India being one of the biggest contributors of these harmful emissions is also the country that has made the largest commitments towards going green. The country has also emerged as a significant international player with the overall modernization of the country prompting it to become an active member of the global community. The goal of this thesis was to explain why India was showing very little growth in nuclear power and provide suggestions on where to go from here in the aftermath of this global pandemic. The inclusion of the benefits of using nuclear power is because security and energy experts do believe that it is where the world is heading. But, in India, nuclear power has not shown much growth and because of COVID-19 more people are in need of the benefits that come with having access to energy. It is not a matter of whether nuclear power is effective, in its own right, but rather that within the context of India's current economic state along with its current nuclear capabilities this source of energy is not going to live up to its current projections. The Indian government needs to reflect on its nuclear projections and realize they are not feasible so they can release a more accurate trajectory. Make no mistake, nuclear power is not going to go away because of its utilization as a security mechanism but if India means to be economically independent in the wake of this pandemic and also stay true to its clean energy commitment than there are a number of other paths the country can choose to take.

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